Experience Report: Mini Guest Lectures in a CS1 Course via Video Conferencing

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ABSTRACT

This paper details the experience of bringing an industry perspective to an introductory programming course, via "mini" interviews conducted during lectures using video conferencing. The novelty of this intervention comes from the frequency, duration and diversity of the industrial involvement. The use of video conferencing lowers the participation barrier for industry professionals and enables a broad range of volunteers to contribute. Our primary goal is to communicate the practical relevance of the materials we teach, and to motivate students to learn and practise course material. We discuss student feedback regarding these interviews collected via an optional, post-facto survey. While there was no quantitative evidence of improved learning outcomes, there was suggestive evidence that students found the interviews motivational, and appreciated learning more about available career paths. We conclude with recommendations to instructors who wish to adopt the intervention.

CCS CONCEPTS

• **Social and professional topics** → **Computer science education; CS1;**

KEYWORDS

CS1, industry professionals, video-conferenced classroom visits

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1 INTRODUCTION

Introductory programming courses teach skills of practical importance. However, it is difficult for a new programmer to appreciate the necessities of testing, the intricacies of naming variables, and even the basic idea of *thinking* before writing code. This report details the experience of bringing industry professionals to a CS1 classroom via short, frequent, video conferenced interviews.

The intervention involved interspersing 10-minute interviews with industry professionals throughout CS1 lectures. These interviews were conducted live via the video conferencing platform Google Hangouts. The professionals were mainly software developers, but also included other professionals who write code on a daily basis. Short, frequent interviews were made viable using video conferencing. The timing of these interviews allowed the instructor to ask professionals questions relevant to a particular week's course material. The professionals answered questions about how they used the material in their day-to-day work, and about their careers.

The primary objective of these interviews was to highlight the relevance of the course content. We hoped that an understanding of how professionals use the course material would motivate students to learn and practice those techniques.

A secondary motivation of these interviews was to showcase diversity in computer science. We interviewed professionals with diverse job titles, backgrounds, ethnicities, and genders. This goal was never explicitly discussed with the students or professionals, to prevent stereotype threat [8].

We conducted a post-facto survey both to collect qualitative student feedback regarding these interviews, and to identify differences between students in a CS1 lecture section that introduced this intervention, and students in a lecture section that did not.

We include in this paper the survey results, insights from the instructor's field notes, and recommendations for fellow computer science instructors who may wish to use a similar intervention.

2 RELATED WORK

Many computer science educators aim to connect students to industry professionals. Beyond a simple guest lecture, educators experiment with involving professional volunteers in a K12 setting [10], and including "industry fellows" in the curriculum development,

planning, and delivery of the course as a co-lecturer [11]. Our intervention differs in the involvement and time commitment of the professionals.

Other related interventions include having an industry professional “in residence” [2], especially for the benefit of underrepresented students. Interactions with female professionals is shown to benefit female K12 students [1]. Industry partnerships like “Women in CSE” seminars linked to CS1 courses provide students with an exploration of potential career paths in computer science [7]. The Hour of Code [6] campaign organizes one-hour introductions to Computer Science for a wide variety of audiences. Like in our intervention, professionals can hold video conferences with students, lowering the cost of volunteering. Our intervention requires even less time commitment from the professionals.

The use of video conferencing in education has also become prevalent [9], mostly as a means to connect students and instructors [4]. Still, Celikkan et al. [5] shows how video conferencing can be used to connect nursing students to real-life situations. Our focus is educating CS1 students by exposing them to different professionals.

3 INTERVENTION CONTEXT

The intervention was conducted at a large, research-intensive North American university, during the summer term of 2018. The CS1 course used the programming language Python, and was taught as a “flipped” or “inverted” class [3]. There were two sections of this course, an afternoon (no treatment) and an evening (treatment) section, taught by different instructors. Each section had an enrollment cap of 195 students. The course consisted of 12 weeks of class, with 3 contiguous hours of lecture per week. As part of the inverted-classroom experience, students watched weekly videos and completed exercises before and after lecture. Students also completed three assignments, one term test, and a final exam.

Each section was taught by one instructor and two teaching assistants. The afternoon (no treatment) section was taught by a male instructor, with two female teaching assistants. The evening (treatment) section was taught by a female instructor, with one male and one female teaching assistant. The professionals interviewed belonged to the network of the treatment section instructor, and were more available during the evening lecture times.

We conducted a pre-course survey, not entirely motivated by this research, to better understand our students. The survey was completed by 234/390 students. We found that the summer student demographics were more diverse than those of the same course in traditional semesters. Students’ intended major fields of study included Computer Science, Statistics, Mathematics, Life Sciences, and others. More than half of students were taking this course as part of their program requirement. While 47% of respondents intended to take additional CS courses, 40% were unsure.

The demographics in the treatment and non-treatment sections were similar. Some (non-statistically significant) differences include more students in the treatment section taking this course as a program requirement (59% vs 54%), and more students in the treatment section (34% vs 27%) requiring additional computer science courses. Still, even if the student demographics were identical, student self-selection of section would continue to be a confounder. Students

had no prior knowledge about the intervention, but were free to attend whichever lecture section they preferred.

4 INTERVENTION

We interviewed five professionals during the 12 weeks of lectures. The anonymized interview schedule is shown in Table 1.

Each interview began with an introduction of the professional, their job title, and their role in their organization. The interview continued with questions based on that week’s lecture topic. The interview concluded with the professional’s advice to students, and student questions.

Frequent interviews meant that we could schedule professionals who could most effectively emphasize the corresponding week’s lecture topic. The professional A was interviewed first because their organization is known for its strict code quality guidelines. The professional C was chosen for the discussion about problem solving because of their role as a Data Scientist.

Short interviews meant that the timing of the interview within a lecture was also flexible. We interviewed B shortly after providing students with a reference sheet of string methods. Just as students wondered which string methods they should memorize (if any), we asked B about which string functions are most often used. As another example, during week 8 of lecture, students spent two hours understanding and modelling a complex coding problem before writing any code. Just as students wondered whether this approach is usual, the interview with C affirmed that, yes, even professionals spend significant time and effort to understand a problem.

Figure 1 provides a sample interview snippet with the professional D. The intention behind the questions about unit tests was to show how pervasive unit testing is in industry. The question about spending time on problem solving was motivated by student surprise in the previous week, when the professional C claimed to spend 30% of time coding versus 70% of time sufficiently understanding the problem.

Scheduling the interviews was not as time consuming as expected. It involved selecting the professionals, asking if they were interested and available, and sending email instructions with potential interview questions. The professionals were very excited to share their expertise and give back to the community. Conducting the interviews via video conferencing was straightforward for the professionals, and allowed us to interview non-local professionals. The professionals were almost always available remotely, so scheduling efforts were minimal.

We recorded the interviews, as part of an initial plan to re-use the videos. All interviewees consented to having the videos recorded

Table 1: Interview Schedule and Topics

Week	Interviewee	Topics
2	A. (Large Co.)	Comments, Naming
4	B. (Medium Co.)	Strings, Constants, Debugging
8	C. (Startup)	Problem Solving, Testing
10	D. (Large Co.)	Testing, Problem Solving
12	E. (Research)	Research, General Next Steps

INSTR: Can you tell us a bit about yourself, what your job title is and what you do?

D: Sure. I've been a software developer since I graduated in 2012, and I am a software development engineer.

INSTR: Very cool! We were talking about testing earlier, can you tell us how you test code where you work?

D: Sure! We write unit tests for each function and module that we write. We have what we call integration tests, where we put multiple functions together and see if they do things together what we want them to do. And then at the very end we load the code up to the device, and then see if it works on the device, because that's what matters the most for customers.

INSTR: So unit tests are what you do first.

D: Yes, that is the most basic test.

INSTR: How often do you write unit tests?

D: Every time I check in code, so every couple days?

INSTR: How often do you run your unit tests?

D: Whenever I make some change to the code, I run tests every few minutes, otherwise I would break something and find out an hour later, I wouldn't know what I changed that caused the break. Also, whenever someone checks in code, there are automatic jobs to run that makes [sic] sure that code didn't break anything else.

...

INSTR: One question from last week where we spent several hours understanding a problem. In your day-to-day work, how much time do you think about a problem versus actually writing code?

D: Me personally, I spend maybe a third of time writing code?

INSTR: One-third writing code, two-thirds thinking.

D: Mostly yes. So the rests are [sic] thinking about different approaches to the problem, and getting others for second opinion.

Figure 1: Sample Interview Snippet

and shared with other CS1 students. However, they were not comfortable with the recorded videos being generally available. Unfortunately, the unedited recordings did not meet the quality expected of a pre-recorded video: the interviews were conducted in a conversational tone, with frequent filter words and pauses that are natural in a live setting but awkward when recorded. We decided not to share the videos with the non-treatment group.

5 DIVERSITY

The instructor made an effort to have a diverse representation in the professionals interviewed. The professionals came from a wide range of ethnic backgrounds. They represented a variety of companies, and a variety of roles within those companies. Two of the five professionals interviewed were women. One professional came from a research background, and the conversation was more related to academic research than industry.

The consideration of diversity was not mentioned to either the professionals or the students. This was intentional, to avoid stereotype threat [8], where being reminded of a stereotype alone may

impact performance. The interview questions were deliberately limited to CS and CS career topics, and avoided diversity related topics. Although there were no explicit instructions to professionals to avoid those topics, they simply did not come up. The intention was to show what diversity in computer science should look like, without drawing any undue attention.

6 KEY LESSONS

This section details the key lessons extracted from a reflective analysis of instructor field notes.

Technical setup. Testing the audio-video system in the lecture room posed some challenges. Fortunately, we did not encounter serious technical difficulties, but could not use the room speakers until the 3rd interview (we used the room microphone with computer speakers, and checked that students could hear). For recording the videos, it was important to record both microphone input (to capture the instructor) and system audio (to capture the professional); not all screen-casting software supports both.

Kicking off. We kicked off the interview with a senior person from a well-known company. Students were impressed by their experience, which captured student attention early on.

Small words. One immediate challenge was that most professionals have little experience speaking to beginning students. After the first interview, the instructor sent clearer instructions to professionals to avoid using jargon, and to avoid topics inaccessible to beginning programmers. After receiving these instructions, the professionals were much more conscious about introducing new material, but still occasionally brought up new concepts. In Figure 3 the professional used the terminologies "integration tests" and "checking in" code.

Short answers. Another challenge was that because the interviews were short, the professional's answers to questions also had to be short. We included in the instructions to professionals to answer questions in about two sentences, and prepare for interruptions. This request was very well taken and followed.

Interview alumni. We found that alumni of our institution were easier for CS1 students to relate to, and generated more honest discussions and better questions. This was true even for alumni who did not take the same CS1 course.

The debugger. During week 4 interviews, B mentioned that even professionals debug on a regular basis. We hoped that this would motivate students to learn to use the debugger. It is normal for CS1 students to resist learning the debugger due to the high learning curve. There was no evidence that the discussion changed student behaviour.

Smartphone vs Laptop. Some professionals used a smartphone instead of a laptop for video conferencing. Using a smartphone reduced the interviewee's eye contact with students, producing a lower quality, shakier video feed, and reduced student engagement.

Student Questions. Some student questions were especially well thought out. For example, students asked C how much math a data scientist uses on a daily / weekly basis. It was encouraging to see students use the opportunity to interact with professionals by asking questions to which answers are difficult to find elsewhere.

Honesty. There were cases where during the interview, the professional did not respond in the way the instructor had expected.

For example, during the discussion about global variable constants, B explained that constants are discouraged in her work. Though the response foiled the intention behind the question, students seemed to appreciate B's blunt honesty.

Canceling an Interview During week 11, there had been an interview scheduled with a discussion centered around Object Oriented Programming. However, the lecture was progressing slower than expected, so the instructor canceled the interview with around 20 minutes notice. The flexibility to cancel meant we could prioritize learning goals and read the atmosphere of the class. In part, this flexibility comes from using video conferencing rather than arranging travel. Of course, we were lucky to have the relationship with a professional that allowed us to cancel.

7 QUALITATIVE SURVEY RESPONSES

An end-of-term survey (Figure 2) was sent to students of both sections. This survey was longer than the pre-course survey, and was conducted after the course concluded. A total of 56 students completed this survey, 30 from the non-treatment group and 26 from the treatment group. The sample size was small, but offered some insight into student thinking. Students were generally positive about the interviews. We summarize the key themes and include a selection of student responses.

7.1 Highlighting Course Relevance

Recall that our primary objective was to highlight the relevance of course materials through the interviews. Student responses from survey sections 5 and 7 provided suggestive evidence that the interviews fulfilled that objective, though some students (in Section 7.5) disagreed. Quotes from student responses to the open-ended questions that illustrate these themes are:

- I thought [the live interviews] provided perspective for our studies and were inspiring.
- I learned what we study that can be use in the future, and which is mostly [sic] important ...
- Computer science is very useful
- ... Coding can be applied in many different applications. Being a programmer is not just about writing sick code; the process of debugging, styling, commenting and algos is important part too.
- Got tons of advice, and saw that classwork built on industry skills.

7.2 Diversity

No student response mentioned ethnic or gender diversity issues, but students appreciated the career diversity of the professionals:

- Anyone can code; it's all about initiative and practice...
- I [liked that] there were a diverse set of individuals from very different companies and cooperations [sic]
- good from a variety of backgrounds/companies, but find similar vein of thought between them all

7.3 Career exploration

While not an original objective of these interviews, students reported gaining a better understanding of the career paths available

1. Consent form Do you consent to participate in this survey?

2. Interest in Computer Sciences To what extent do you agree/disagree with the following? (Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree)

- At the beginning of the term, I intended to take more computer science courses.
- I intend to take more computer science courses.
- I am interested in a career in computer science.
- I believe that anyone, regardless of where they come from, can succeed in computer science.

3. How important do you feel are the following for a programmer? (1-not important; 7-very important)

Coding	Style checker
Commenting	Thinking
Unit tests	String Methods
Classes	Debugging

4. Which Lecture Section Did you Attend?

o Afternoon (Continue to 8) o Evening (Continue to 5)

5. Live Interviews If you attended evening section lectures, were you in class when we conducted interviews with ...
What are 3-5 things that you learned from the live interviews?
Was there anything you did not expect? [free form responses]

6. Live Interviews To what extent do you agree / disagree with the following? (Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree)

- The interviews helped me understand how material taught in class is relevant to industry professionals.
- The live interviews improved my understanding of what computer science professionals do.
- The live interviews increased my interest in CS.
- The time could have been better spent on other topics (worksheets, shorter class).

7. Live Interviews

- What did you think about the live interviews?
- What did you like?
- What didn't you like?
- Is there anything else we should know?

8. Demographic

- What is your major?
- Do you identify as a woman?
- Do you identify as a person of visible or ethnic minority?

Figure 2: Post-Facto Survey Questions

to computer science graduates. Students appreciated the opportunity to meet professionals across a a wide range group of occupations and contexts. For example, students said:

- I like how you took the initiative to show us that [sic] the CS industry is like outside of the classroom. Thank you!
- I learned that computer science can be used in many different fields.
- Really good to see what a future in CS potentially looks like
- Maybe [because] I have not seen it before, it is certainly a new and interesting experience

- [I liked] hearing about their schooling and how they got into compsci.
- I like [to] talk to people who have experience face to face.
- Liked that these meetings resulted in increased awareness of job applications for future

7.4 Student Questions

A few students mentioned that they found the student question portion of the interview valuable. The quality of student questions varied: some interviews generated insightful questions, and others generated none at all. In the future, students might benefit from guidance on how to ask good questions, or a way to pose questions anonymously.

- Liked how [interviewees] were open to answering questions.
- Well I probably should not say this (since I did not ask any question), but I was hoping my classmates could ask more questions.
- I just like the idea of live interview with computer science professionals (live does make it better).

7.5 Negative Responses

The negative responses pointed to areas for improvement. Since this course included a diverse group of students, many of whom were not CS majors, some students may have felt that learning about careers in this field was uninteresting:

- I think they're all interesting people with interesting career paths but i hate this field and its offputting to me.
- Literally didn't relate to what I want to do in life at all.
- The field is not intriguing to me
- I wasn't particularly interested

Some students did not believe that the interviews helped their learning, or preferred to spend time reviewing core concepts.

- [The interviews were] not super useful [because] I think people would rather have that time spent on going over some materials they're having trouble with.
- [I liked that] they killed some time
- I didn't feel it necessary helped my learning
- They didn't seem to actually promote the lessons which the professor wanted. Often times underplaying the importance of certain aspects; nonetheless it was nice to know that computer scientist/ software engineers still make use of the basic principles which were taught in class.

Other student responses pointed to the professional's difficulty in avoiding complex topics, and the interview logistics.

- Sometimes the interview got too complex and deep within computer science terminology to be helpful.
- Short time allotted to interviews, should have been longer.
- A stronger internet connection or proper [audio] speakers would be nice.

8 QUANTITATIVE SURVEY RESPONSES

In this section we analyze the quantitative survey results, comparing between the non-treatment and treatment sections. Six respondents who were in the treatment section, but who were present for fewer than two interviews were discarded from the data. As a result, the treatment section included 20 data points, and the

Figure 3: Interest in CS Questions

non-treatment section 30. Out of the survey respondents, 9 of 20 treatment group students and 12 of 30 non-treatment group students identified as a woman.

8.1 Interest in Computer Science

Figure 3 summarizes student responses related to their interest in CS, and their belief that anyone can succeed in the field. The treatment section appears to be more “decisive” (fewer neutral answers) in their intention to take more CS courses, but the difference is not statistically significant (Wilcoxon rank-sum test). There are also no statistically significant differences between the two sections’ beliefs that anyone can succeed in computer science.

8.2 Importance of CS Topics

Student response to the importance of CS topics (survey section 3) did not yield interesting results. The interviews emphasized certain topics (commenting, unit tests, style checker, thinking, debugging), omitted other topics (classes), and downplayed others (string methods). However, differences between the two sections were minimal.

8.3 Attendance

Respondents in the evening section (treatment group) attended an average of 3 interviews. As usual, student attendance at the beginning of the term was higher than at the end of the term.

Figure 4: Interview Relevance Questions

8.4 Live Interview

Figure 4 shows that the reactions to the interviews among treatment group respondents were generally positive. There was general agreement that the interviews helped students understand the relevance of course material, and provided an understanding of what professional practitioners do. This result corroborated the written student responses presented in earlier sections.

Students also self-report that the interviews increased their interest in CS, although this result differs from those in Figure 3.

Students were split on whether the time could have been better spent in other ways, again corroborating the qualitative responses.

9 CONCLUSION

We report our experience interspersing short, 10-minute interviews with professional programmers in a CS1 classroom. Survey results show that, in general, students found these engaging, motivating, and appreciated learning about available career paths. Figure 5 summarizes key recommendations for fellow computer science instructors who wish to apply similar interventions.

One key question is whether the trade-off of lost lecture time was worthwhile. Student opinion on the matter was split. The tradeoff depends on available class time and student interest in a CS career. We ended our CS1 course an hour early, suggesting that there was ample lecture time available. However, lecture time was less “tight” near the beginning and end of the course. The intervention would have been more effective if more of our students were CS majors as opposed to non-majors, who would be more interested in learning more about CS career paths.

Another tradeoff is between contact with instructor, and contact with a different type of “authoritative” person. We hoped that professionals may be able to motivate students in ways that instructors

- 1. Use live video conferencing.** Video conferencing simplifies scheduling and lowers the professionals’ time commitment.
- 2. Ask professionals to use a laptop.** Using a smartphone instead will produce a shakier and more blurrier video feed with a narrower aspect ratio, and the professional will make less eye contact.
- 3. Videos won’t be reusable.** If a reusable video is desired, recording it without the presence of students will increase its quality. Professionals generally consent to being recorded, but not for the recording to be public.
- 4. Ask professionals to use small words and give short answers.** Describe ahead of time concepts students are familiar with, and give examples of concepts to avoid. Shorter responses will keep the conversation moving.
- 5. Start with a BANG!** Kick-off the interview series with a professional from a well-known company, to engage student attention immediately.
- 6. Interview alumni.** Alumni understand students more deeply, and students identify with them.
- 7. Choose professionals that align with student goals.** For example, we chose a data scientist based on observed student interest in artificial intelligence. Ideally, we would have also chosen a medical researcher who programs regularly, since we had many life sciences students.
- 8. Be intentional about the learning goals.** The selection of professionals for each lecture and the timing of the interviews should complement the learning goals. In case class progresses slower than usual, it is beneficial to have the flexibility to cancel.
- 9. Ask the professionals to be honest.** Disagreements between the instructor and the professional engage students.
- 10. Student questions can be insightful.** Students took the opportunity to ask questions that only professionals can answer, and that are difficult to find answers to online.

Figure 5: Recommendations

cannot. Though the survey evidence is not conclusive, the interviews did surprise students in ways that the instructor could not: e.g. just how important it is to understand the problem.

Finally, conducting the interviews via video conferencing was undoubtedly more flexible than doing so in-person. It is difficult to justify asking a professional to travel to campus for a mere 10-minute discussion, so an in-person interview would have required even more lecture time, and likely an entirely different setup.

Given the opportunity to teach a CS1 course comprised mainly of CS majors, we would repeat the intervention, perhaps adjusting the timing and quantity of the interviews to better reflect the learning and career goals for that audience.

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REFERENCES

- [1] Catherine Ashcraft, Elizabeth Eger, and Michelle Friend. 2012. Girls in IT: the facts. *National Center for Women & IT. Boulder, CO* (2012).
- [2] Legand Burge, Marlon Mejias, KaMar Galloway, Kinnis Gosha, and Jean Muhammad. 2017. Holistic Development of Underrepresented Students through Academic: Industry Partnerships. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education*. ACM, 681–682.
- [3] Jennifer Campbell, Diane Horton, Michelle Craig, and Paul Gries. 2014. Evaluating an inverted CS1. In *Proceedings of the 45th ACM technical symposium on Computer science education*. ACM, 307–312.
- [4] Duygu Candarli and H Gulru Yuksel. 2012. Students' perceptions of videoconferencing in the classrooms in higher education. *Procedia-Social and Behavioral Sciences* 47 (2012), 357–361.
- [5] Ufuk Celikkan, Fisun Senuzun, Dilek Sari, and Yasar Guneri Sahin. 2013. Interactive videoconference supported teaching in undergraduate nursing: A case study for ECG. *Journal of Educational Technology & Society* 16, 1 (2013), 286.
- [6] Jie Du, Hayden Wimmer, and Roy Rada. 2016. "Hour of Code": Can It Change Students' Attitudes toward Programming? *Journal of Information Technology Education: Innovations in Practice* 15 (2016), 52–73.
- [7] Crystal Eney and Crystal Hoyer. 2005. Making a Difference on \$10 a Day: Creating a "Women in CSE" Seminar Linked to CS1. In *Proceedings of the American Society for Engineering Education*.
- [8] Amruth N Kumar. 2012. A study of stereotype threat in computer science. In *Proceedings of the 17th ACM annual conference on Innovation and technology in computer science education*. ACM, 273–278.
- [9] Tony Lawson, Chris Comber, Jenny Gage, and Adrian Cullum-Hanshaw. 2010. Images of the future for education? Videoconferencing: A literature review. *Technology, Pedagogy and Education* 19, 3 (2010), 295–314.
- [10] Anthony Papini, Leigh Ann DeLyser, Nathaniel Granor, and Kevin Wang. 2017. Preparing and supporting industry professionals as volunteer high school computer science co-instructors. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education*. ACM, 441–446.
- [11] Josh Tenenbergs. 2010. Industry fellows: bringing professional practice into the classroom. In *Proceedings of the 41st ACM technical symposium on Computer science education*. ACM, 72–76.